NASA Innovative Advanced Concepts

Variable Vector Countermeasure Suit for Space Habitation and Exploration (V2Suit)

Completed Technology Project (2012 - 2014)

Project Introduction

The "Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration" is a visionary system concept that will revolutionize space missions by providing a platform for integrating sensors and actuators with daily astronaut intravehicular activities, and testing the interactions between countermeasures to improve human health and adaptation countermeasures. The V2Suit uses control moment gyroscopes within a miniaturized module placed on the major segments of the body to provide a "viscous resistance" during movements – a countermeasure to the sensorimotor and musculoskeletal adaptation performance decrements that manifest themselves while living and working in microgravity, and during gravitational transitions during long-duration spaceflight, including post-flight recovery and rehabilitation. Effective countermeasures to this de-conditioning and the unique sensorimotor characteristics associated with living and working in 0-G are critical for future space missions. This proposed project is a follow-on to the current NIAC Phase I V2Suit, which is exploring the concept and maturing the technology through proof-of-concept simulation and limited hardware-in-the-loop testing. A technology readiness level of 2 is expected at the end of Phase I, and through further Phase II study and brassboard unit development the technology readiness level is estimated to be an early 4. This proposed Phase II project has four integrated aims for further development of the concept studied in the Phase I award, assessing the V2Suit in a mission context, and assessing the programmatic benefits – all contributing to a technology development roadmap for operational demonstration. (This is a project within the NASA Innovative Advanced Concepts, NIAC, program.)

Anticipated Benefits

The Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration is a visionary system concept that will revolutionize space missions by providing a platform for integrating sensors and actuators with daily astronaut intravehicular activities to improve human health and performance.

Project Image Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration

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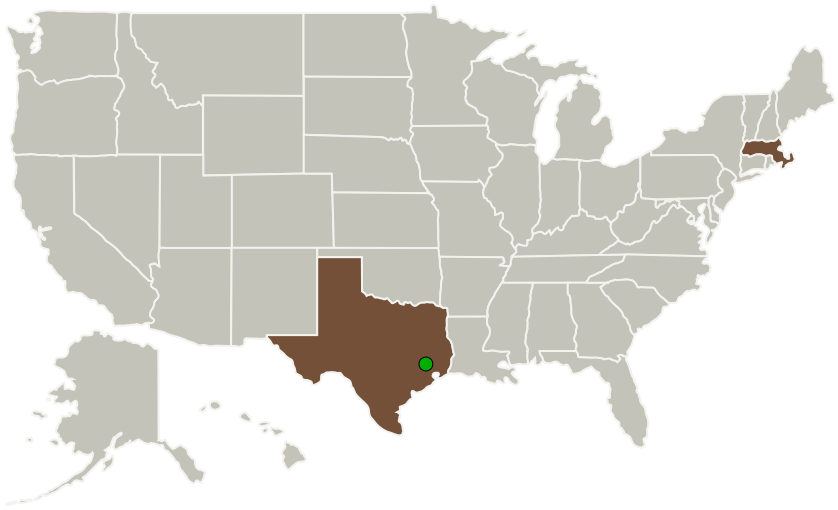
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
The Charles Stark Draper Laboratory, Inc.	Lead Organization	R&D Center	Cambridge, Massachusetts
David Clark Company Incorporated	Supporting Organization	Industry	Worcester, Massachusetts
Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas
Massachusetts Institute of Technology(MIT)	Supporting Organization	Academia	Cambridge, Massachusetts
University of Houston	Supporting Organization	Academia	Houston, Texas

Primary U.S. Work Locations	
Massachusetts	Texas

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

The Charles Stark Draper Laboratory, Inc.

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

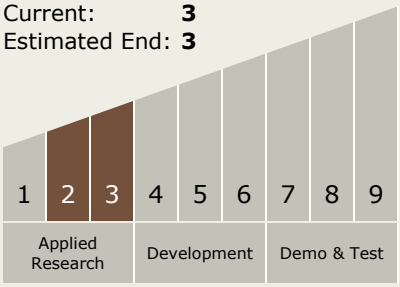
Eric A Eberly

Principal Investigator:

Kevin W Duda

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Project Transitions

September 2012: Project Start

August 2014: Closed out

Closeout Summary: The Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration is a visionary system concept that will revolutionize space missions by providing a platform for integrating sensors and actuators with daily astronaut intravehicular activities to improve human health and performance. The V2Suit uses control moment gyroscopes (CMGs) within a miniaturized module placed on body segments to provide a viscous resistance during movements - a countermeasure to the sensorimotor and musculoskeletal adaptation performance decrements that manifest themselves while living and working in microgravity and during gravitational transitions during long-duration spaceflight, including post-flight recovery and rehabilitation. Through an integrated design, system initialization, and control systems approach the V2Suit is capable of generating this viscous resistance along an arbitrarily specified direction of down. When movements are made, for example, parallel to that down direction a resistance is applied, and when the movement is perpendicular to that direction no resistance is applied. The V2Suit proposes to be a countermeasure to this spaceflight-related adaptation and de-conditioning and the unique sensorimotor characteristics associated with living and working in 0-G, which are critical for future long-duration space missions. This NIAC Phase II project leveraged the study results from Phase I and focused on detailing several aspects of the V2Suit concept, including a wearable CMG architecture, control steering laws, human-system integration evaluations, developing a brassboard prototype unit as a proof-of-concept, as well as evaluating the concept in the context of future space exploration missions. A human mission to Mars, such as that outlined in the Mars Design Reference Architecture 5.0, provides a framework for determining the concept of operations and requirements for the V2Suit system. Mars DRA 5.0 includes approximately 180 day 0-G transits to- and from- Mars, as well as a 500 day stay on the surface (~3/8-G) (Figure 3). Accordingly, there are four gravitational transitions associated with this mission: 1-G to 0-G (Earth launch), 0-G to 3/8-G (Mars landing), 3/8-G to 0-G (Mars launch), and 0-G to 1-G (Earth landing). This reference mission provided the basis for developing high-level operational requirements to guide the subsequent study and design of the key V2Suit components.

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.5 Structural Dynamics
    - TX12.5.2 Vibroacoustics

Target Destinations

Earth, The Moon, Mars

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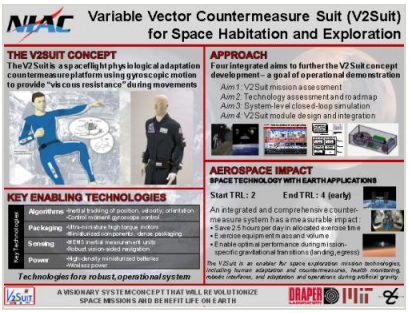
Images



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Project Image Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration
(https://techport.nasa.gov/image/102318)

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Project Image Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration
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Project Image Variable Vector Countermeasure Suit (V2Suit) for Space Habitation and Exploration
(https://techport.nasa.gov/image/102117)

Links

Patent Link 1
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